United States
Department of
Agriculture

Forest
Service

Southwestern
Region

Forest Pest Management Report

3420

R3 96-2

Roundheaded Pine Beetle in the Pinaleno Mountains: Results of a Re-Survey of the Riggs Lake Area

3420
R-3 96-2

Roundheaded Pine Beetle in the Pinaleno Mountains
Results of a Re-Survey of the Riggs Lake Area

May 1996

Prepared by

Jill L. Wilson
Entomologist

USDA Forest Service, Southwestern Region
Arizona Zone Entomology and Pathology
2500 S. Pine Knoll Dr.
Flagstaff, Arizona 86001

SYNOPSIS

An outbreak of the roundheaded pine beetle, Dendroctonus adjunctus, has caused elevated levels of ponderosa pine mortality in the Pinaleno mountains of southern Arizona since 1991. In late 1992 Arizona Zone Entomology and Pathology (AZEP) personnel conducted a survey in the Riggs Lake recreation area to evaluate effects, trends and management alternatives for the outbreak. The outbreak continued through 1993 and 1994. In August 1994 AZEP personnel conducted another survey in the same areas to document the effects of the outbreak. By 1994 the outbreak had subsided for the most part in the Riggs area. Few currently infested trees were detected. In the wake of the outbreak though, effects to the area were substantial. Stand densities were reduced up to 41 percent (square feet of basal area) and the proportion of ponderosa pine was reduced up to 79 percent. The outbreak hastened the replacement of ponderosa pine with non-host species in the Riggs area and throughout the mixed pine forest type. Management practices that reduce densities, and create a mosaic of stand conditions and favor appropriate species for the site should reduce the forest susceptibility during future outbreaks.

INTRODUCTION

Ponderosa pine mortality, largely caused by the roundheaded pine beetle, Dendroctonus adjunctus, has been occurring at elevated levels in the Pinaleno mountains since 1991. The roundheaded pine beetle (RPB) (Coleoptera: Scolytidae) occurs throughout the southwest and is found on ponderosa pine, white pines and Chihuahua pine. It is one of the most common tree killing bark beetles affecting pines in the the southern portions of Arizona and New Mexico. This insect produces one generation per year, with the main flight and attack period in October and November.

One other outbreak, fairly limited in size, has been reported in the Pinalenos. It occurred in the sixties and was concentrated in the Riggs Flat area. Historical records indicate that it covered about 640 acres at its peak.

The present outbreak also started in the Riggs Flat/Merrill Peak area as well as around Heliograph Peak. In 1992 mortality intensified in these areas and began appearing in the area around Treasure Park. In November of 1992, personnel from AZEP with the assistance of folks from the Safford Ranger District, conducted a survey of beetle activity and stand conditions in the area around Riggs Lake. Results of this survey are reported in Forest Pest Management Report R3 93-1 (Wilson 1993). In 1993, activity appeared on the north side of the Pinalenos, generally in the vicinity of Webb Peak and sections to the east, as well as on West Peak. The outbreak continued in 1994, but no new areas of mortality were detected. In early August, 1994, Jill Wilson, Entomologist, Borys Tkacz, Arizona Zone Leader and Kim Kennedy, Biological Technician, resurveyed the Riggs Flat area. The purpose of this survey was to determine current roundheaded pine beetle activity in the area, and to describe the effects to date of the outbreak, and to project future outbreak trends. This report summarizes the results of that survey.

METHODS

Survey methods used in 1992 were repeated in 1994. In 1992, three zones of infestation were identified in the Riggs Lake area by Steve Dudley, Biological Technician, AZEP, during the aerial detection survey (Fig 1). In each area a systematic variable plot/fixed plot cruise was used to estimate bark beetle activity and current stand conditions. Two transect lines, 8 chains apart, were placed along the longest axis of each zone. Points were established at 5 chain intervals along each line. Neither the starting point nor the sample points were permanently marked in the 1992 survey, however, approximate start positions could be determined from maps. At each point a variable plot (35 basal area factor) and a fixed plot (1/100 acre) were established. For all sample trees, species, diameter, tree condition (healthy, infested, or dead), and cause of injury or death were recorded. Stumps located around the plots were also measured (diameter inside bark at stump height) and used to estimate tree size prior to removal. Estimated diameter and the distance from plot center was used to determine if the tree would have fallen inside or outside of the plot. It was assumed that all stumps were trees killed by the roundheaded pine beetle. From this information trees per acre (TPA) and square feet of basal area per acre (BA) were calculated by species, diameter class (dbh), tree condition and causal agent by zone. In this report only results for the overstory plots are described. If information is needed on the understory it may be found in our 1993 report (Wilson 1993). Though we had intended to try to estimate the year of attack in the dead pines, we found this very difficult, if not impossible, to determine because this insect has two flights per year, a big flight in fall and a smaller one in spring.

RESULTS AND DISCUSSION

Bark beetle caused mortality had declined throughout the Riggs survey area by 1994. Very few currently attacked trees were found in 1994. The proportion of ponderosa pine in the Riggs area has been reduced dramatically as a result of this outbreak. Overall numbers reported for basal area and trees per acre varied somewhat from 1992 to 1994. This is to be expected since the exact points were not remeasured and stand conditions within each of the survey zones were variable.

In Zone 1, the area located just to the west of Merrill Peak, pre-outbreak conditions were estimated to be 245 square feet and 290.2 trees per acre (Figures 2 and 3). Post outbreak densities (live trees) were estimated to be 212.5 square feet and 260.6 trees per acre. This represents an 11 percent reduction in density (both basal area and trees per acre) overall. This area was the least affected by the outbreak since it had relatively fewer ponderosa pine than the other areas sampled (Figure 4, Tables 1-4). Still as a result of the outbreak, over 50 percent of the ponderosa pine 6 inches and greater had been killed by 1994 (Tables 5-6). On our survey plots, all pines between the sizes of 8 and 14 inches were killed (Table 9). Mortality rates varied for larger size classes. Southwestern white pine was also affected, but to a lesser degree (Tables 7-8). The overall mortality rate for this species in this zone has been 5.6 percent.

In Zone 2, located north of Merrill Peak and Riggs Lake, pre outbreak conditions were estimated to be 249.1 square feet of basal area and 297.9 trees per acre while post outbreak densities were estimated to be 172.7 square feet, and 204.4 trees per acre in 1994 (Figures 2-3). This represents a 31 and 32 percent reduction in basal area and trees per acre respectively. Very few infested trees were found in this area, all white pines (Tables 5-8). Roundheaded pine beetle has had a significant impact on this stand. Before the outbreak 36 % of the trees were ponderosa pine (39 % of the basal area), by 1994 ponderosa pine constituted only 11 % of the trees and 16 percent of the basal area (Figure 5, Tables 1-4). Overall, 79% of the ponderosa pine 6 inches and greater were killed (Table 6). All diameter classes were affected. The greatest number of trees killed occurred in the 6,8,10,12, and 14 inch diameter classes, which also possessed the greatest number of trees to begin with (Table 10). Effects to southwestern white pine were minimal in this zone as in zone 1. The overall mortality rate was 4.4 percent.

In Zone 3, located west of Riggs Lake, pre-outbreak densities were estimated to be 183.6 square feet of basal area and 209.0 trees per acre (Figures 2 and 3). Post outbreak densities were estimated to be 109.1 square feet of basal area, and 149.1 trees per acre in 1994. This represents a 41 percent reduction in basal area and a 29 percent reduction in trees per acre. This zone, like zone 1 had a substantial ponderosa pine component prior to the outbreak (Figure 6, Tables 1-4). In this survey only a few currently infested trees were found in the area, including some ponderosa and some white pines (5.8 per acre) (Tables 5 - 8). Seventy eight percent of the ponderosa pine trees 6 inches and greater were killed in this area, 67 percent of the basal area. All diameter classes were affected. Southwestern white pine was affected but to a small degree as in the other areas.

Overall, the outbreak in the Riggs Lake area had subsided by 1994 as indicated by the scarcity of newly infested trees in the 1994 survey. Figure 7 displays the overall course of the outbreak between 1989 and 1995 as detected during annual aerial detection surveys. Populations peaked in 1993 with the number of trees fading peaking the following year. In its wake, the roundheaded pine beetle has had a significant influence on the density, structure, and species composition of the Riggs Lake area. Densities were reduced 11 to 41 percent and some canopy gaps have been created. The outbreak has removed a substantial portion of the ponderosa pine component in the area. This may be a significant concern since many of these sites were pine sites maintained over time through frequent fires. Through the combined actions of fire exclusion and the beetles, this species is being replaced by other species. This will likely have repercussions in the future as some of these species are more susceptible to other insects and pathogens on these sites as well as to drought. In addition, the outbreak created an abundance of dead and down trees which were reported to be a factor in the recent Clark Fire. Still, in spite of the number of trees killed, densities in many areas are still quite high, particularly in those areas where ponderosa pine was not the predominant species prior to the outbreak, such as in zones 1 and 2 in the Riggs Lake area. In these areas susceptibility to other bark beetle species may remain high. This outbreak and any future outbreaks will also contribute to increased fire hazard through creation of small and large woody fuels.

A variety of management practices could be used to help restore the mixed pine ecosystem and the Riggs Lake area to a more sustainable condition both from the

standpoint of beetle hazard as well as other factors. These include a variety of silvicultural treatments, both even and unevenaged, that could be used to manipulate species composition, stand structure and stand density. The aim of these treatments would to create a mosaic of conditions that would serve to break up the landscape, making it less vulnerable to catastrophic events. Reintroduction of prescribed fire would also be beneficial.

TECHNICAL INFORMATION

The roundheaded pine beetle, Dendroctonus adjunctus Blandford, occurs throughout the southwest and may be found on ponderosa pine, white pines, and Chihuahua pine. It is often mistaken for other species, such as the mountain pine beetle, which it resembles. This insect produces one generation per year. The main attack period is during October and November. Foliage usually fades the following year in May or June (Chansler 1967). A portion of the population atacks in May or early June (Wood 1982).

External evidence of attack consists first of pitch tubes and later fading foliage. Underneath the bark, egg galleries wind longitudinally with the grain and average 31 centimeters in length (Wood 1982). Galleries are numerous and often cross (Chansler). As with other Dendroctonus spp. egg galleries are packed with frass. Larval galleries are generally at right angles to the parent galleries. Larvae first feed in the inner bark but complete development in the dry outer bark (Chansler 1967).

In the Southwest, this insect usually attacks and kills weakened ponderosa pines. The average diameter of attacked pines from past outbreaks in New Mexico has varied from 9 inches in the 1960's to 6.5 inches in the 1970's outbreak (Chansler 1967, Stevens et al 1974). In addition, Stevens et al (1974) reported that mortality was concentrated in the codominant trees. Meanwhile, outbreaks in southern Nevada have been primarily restricted to larger size classes (Massey et al 1977).

Outbreaks of the insect have been reported from southern New Mexico, Arizona and Nevada. In New Mexico, outbreaks have occurred approximately at 10 year intervals since the 1950's (Massey et al 1977). The largest outbreak occurred in the 1970s and affected 150,000 acres. The recent outbreak there affected 87,000 acres. In the Sacramento Mountains in New Mexico there has been a trend toward increasing outbreak size during this century. Prior to the 1970 outbreaks involved 10,000 or fewer acres, but since 1971 the outbreaks involved 100,000 or more acres acres (FPM staff, 1995). During outbreaks, trees are generally attacked in groups of 3 to 15, although some groups may contain more than 100 trees (Chansler 1967). The outbreak in the 1970's resulted in reductions of up to 50 percent in both trees per acre and basal area (Stevens et al 1974).

Several factors have been reported to be associated with outbreaks of the roundheaded pine beetle. Massey and others (1977) report that outbreaks seem to develop on poorer sites and ridgetops. Recent work in the southwest suggests that roundheaded pine beetle prefers forest conditions characterized by high basal areas, and slow growth (Negron 1996).

Bark beetle outbreaks result in a number of direct and indirect effects on forests. The obvious effect is tree mortality. However as a result of this, bark beetle outbreaks can significantly modify forest conditions, including species composition, density and structure. Outbreaks can affect successional changes in forests, promoting succession in some cases while setting it back in others. Effects on forest resources include decreased timber production and value, creation of hazard trees in recreation areas, increased water yields, increased forage production, increased food and habitat for some wildlife species while decreasing the same for others, and increased fire hazard.

No management guidelines have been described specifically for this insect, however, preventive measures described for other Dendroctonus spp. should be appropriate. Thus, treatments that reduce competition and disease levels, as well as encourage diversity across the landscape should reduce susceptibility. For many Dendroctonus species, entomologists recommend maintaining basal areas below 120 square feet and creating a mosaic of age classes across the landscape.

LITERATURE CITED

Chansler, J.F. 1967. Biology of Dendroctonus adjunctus. Annals of the Entomological Society of America, 60:760-767.

Forest Pest Management Staff 1995. Insects and Disease: Indicators of Forest Health, A Forest Health Briefing Paper. USDA Forest Service, Southwestern Region, Forest Pest Management Report R3 95-02. 29 pp.

Massey, C.L., D.D. Lucht, and J.M. Schmid. 1977. Roundheaded Pine Beetle. USDA Forest Service, Forest Insect and Disease Leaflet 155. 8 p. Washington D.C.

Negron, J.F., D.Bennett, and J.Wilson. Estimating the Probability of Infestation by the Roundheaded Pine Beetle, Dendroctonus adjunctus Blandford, in the Sacramento Mountains, New Mexico. Poster Abstract submitted to the Proceedings of the 2nd North American Forest Insect Work Conference, 8-12 April, 1996, San Antonio TX.

Stevens, R.E. and H.W. Flake, Jr. 1974. A Roundheaded Pine Beetle Outbreak in New Mexico: Associated Stand Conditions and Impact. USDA Forest Service Research Note RM-259. 4 p.

Wilson, J.L. 1993. Biological Evaluation of a Roundheaded Pine Beetle Outbreak in the Pinaleno Mountains, Safford Ranger District, Coronado Nation Forest. USDA Forest Service, Southwestern Region, State and Private Forestry and Forest Pest Management Report R3 93-1, 27pp.

Wood, S.L. 1982. The Bark and Ambrosia Beetles of North and Central America (Coleoptera:Scolytidae), a Taxonomic Monograph. Great Basin Naturalist Memoirs. Brigham Young University. 1359 p.

Figure 1

Zones and Transect Lines for Riggs Survey

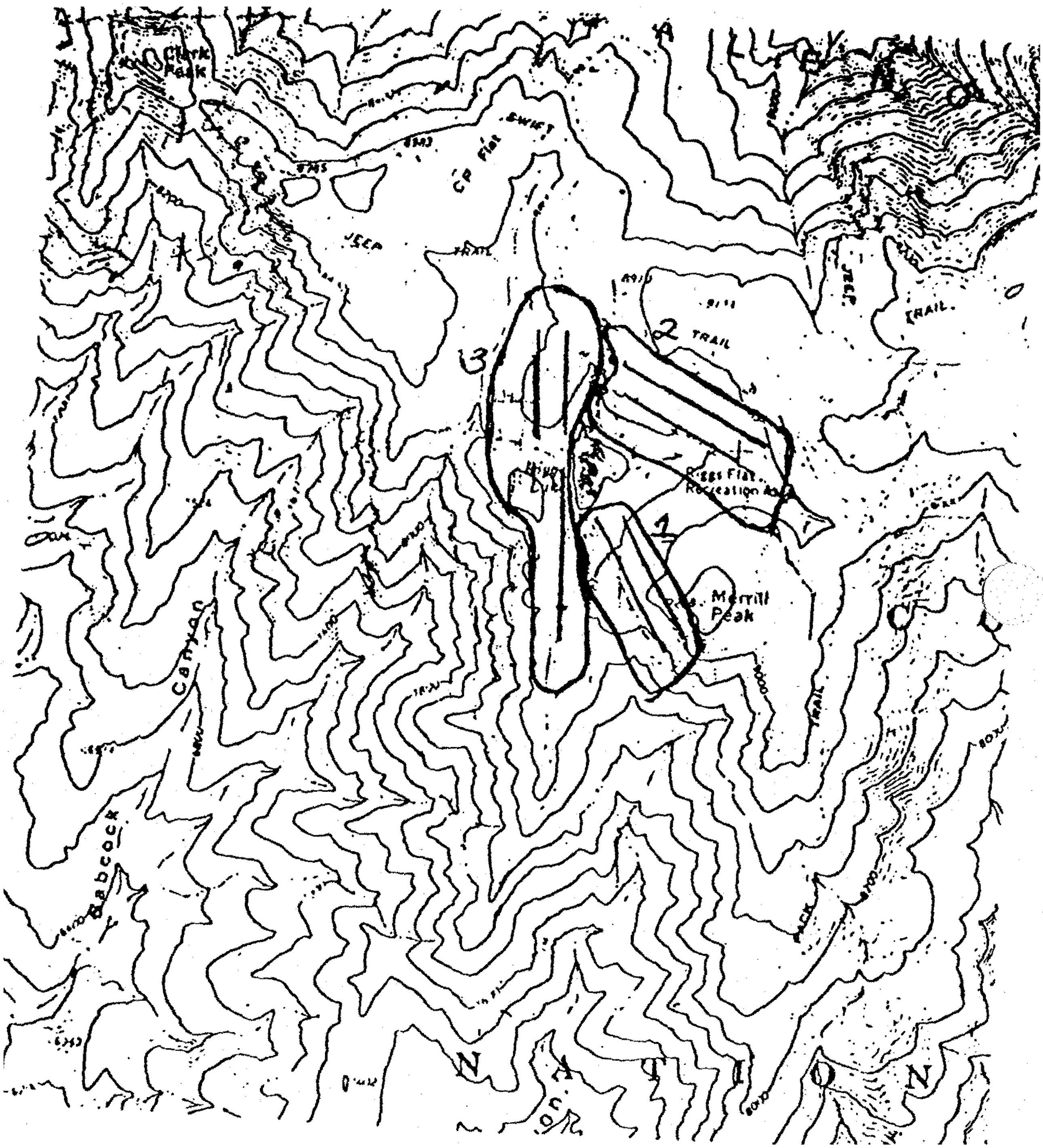


Figure 2
Changes in Basal Area Pre and Post Outbreak

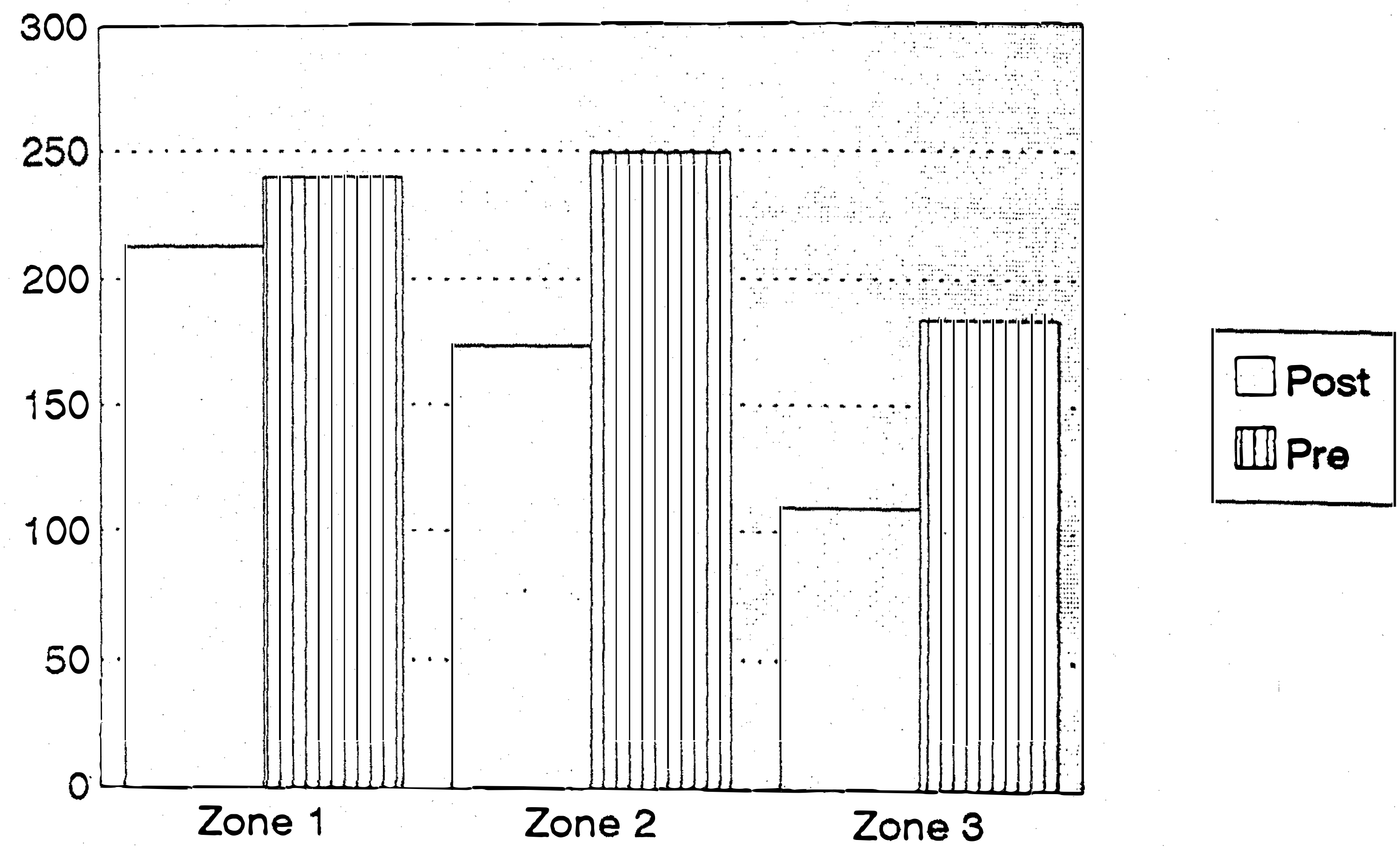


Figure 3
Changes in TPA Pre and Post Outbreak

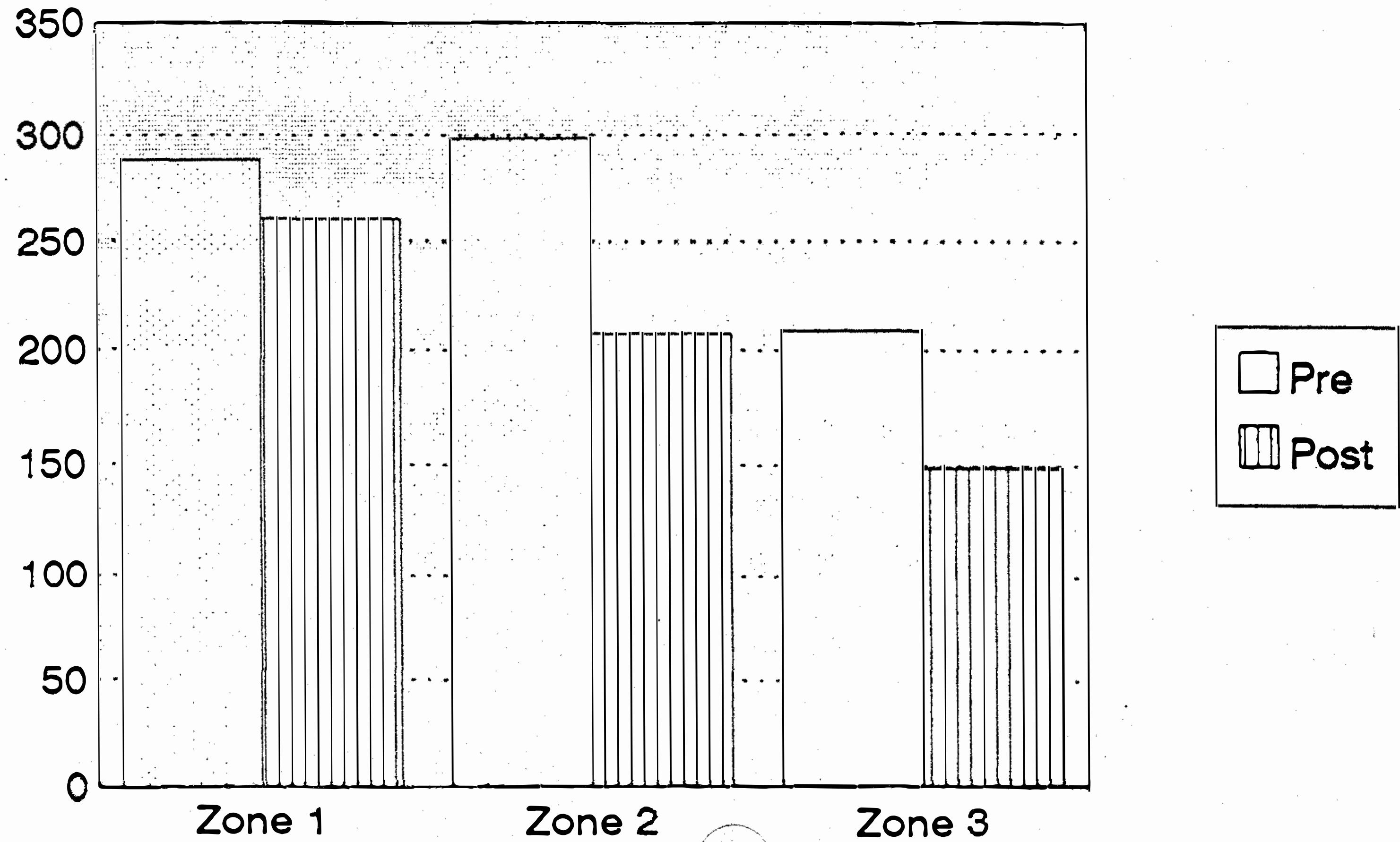
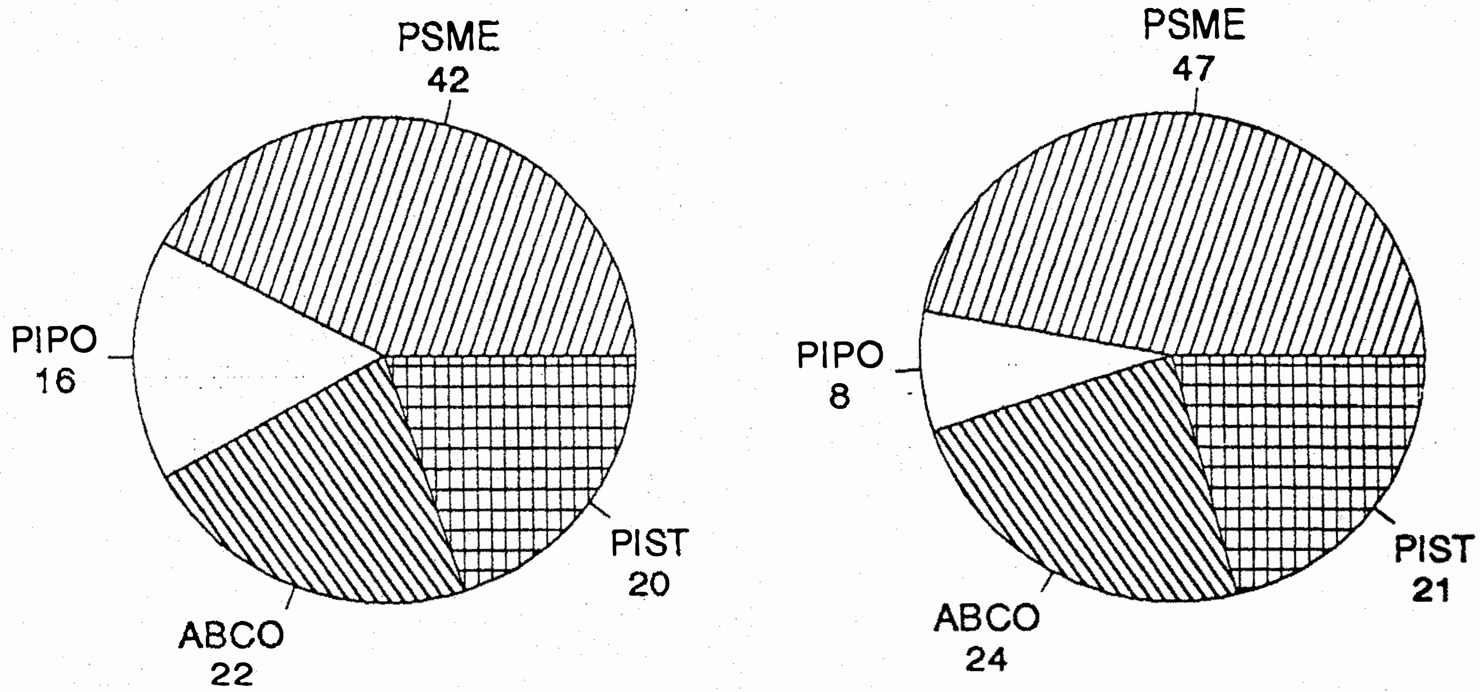
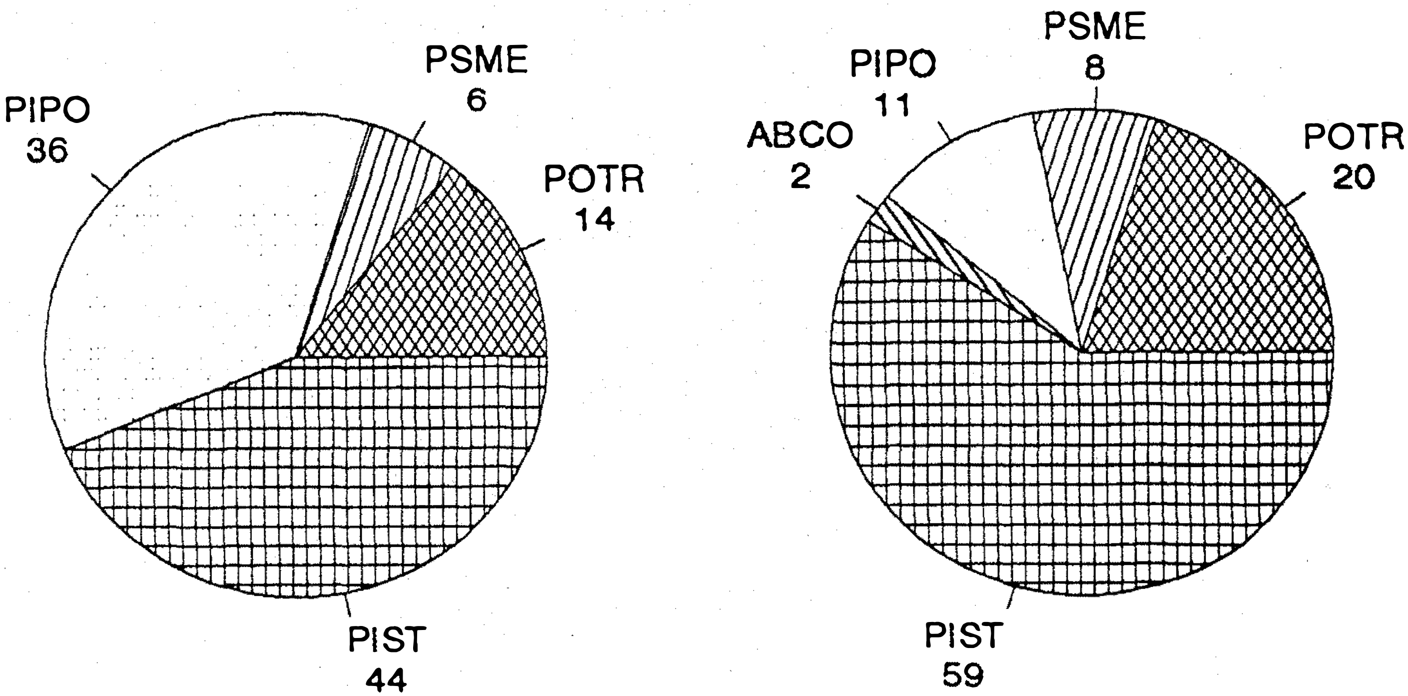


Figure 4
Changes in Spp. Composition: Zone 1



Pre Outbreak TPA   Post Outbreak TPA

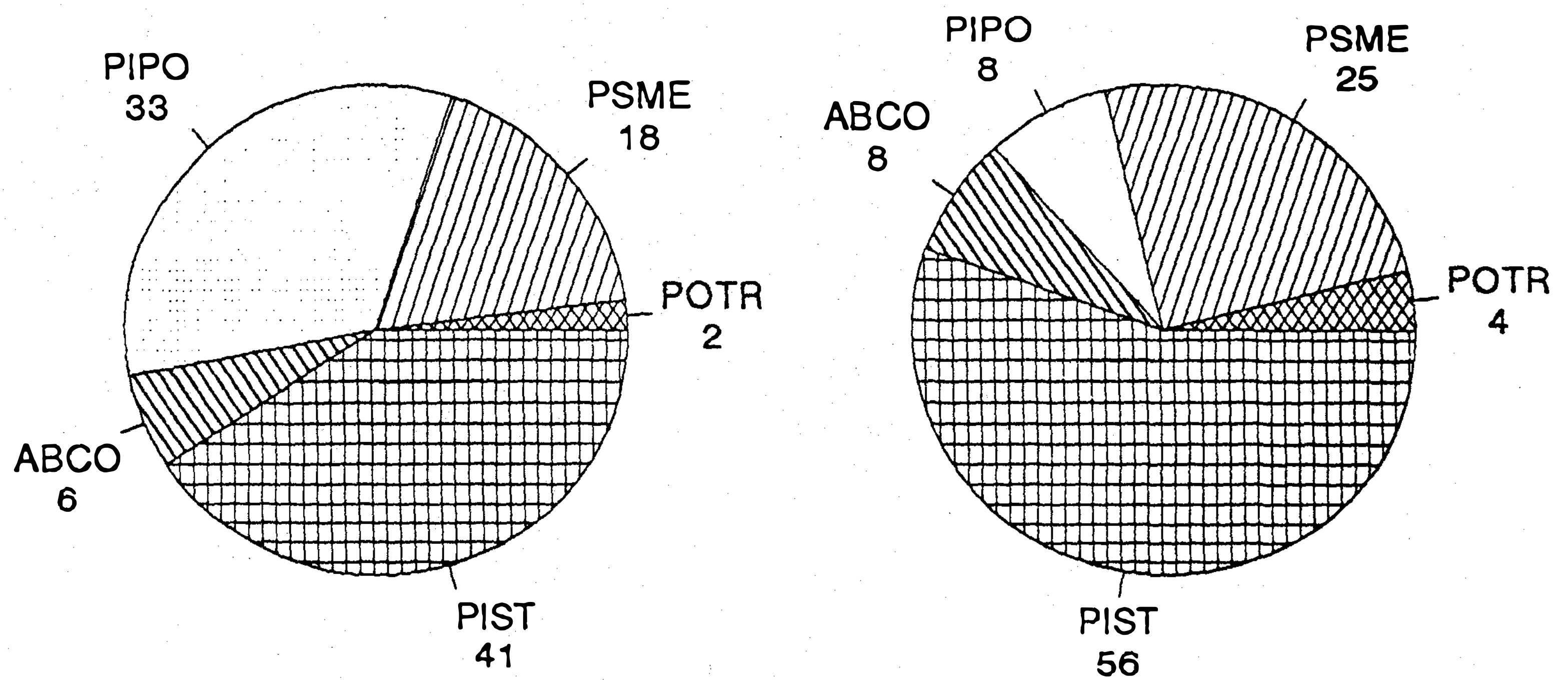
Figure 5
Changes in Spp. Composition: Zone 2



Pre Outbreak TPA

Post Outbreak TPA

Figure 6
Changes in Spp. Composition: Zone 3



Pre Outbreak TPA

Post Outbreak TPA

Figure 7
Acres and Number of trees Killed by Roundheaded Pine Beetle

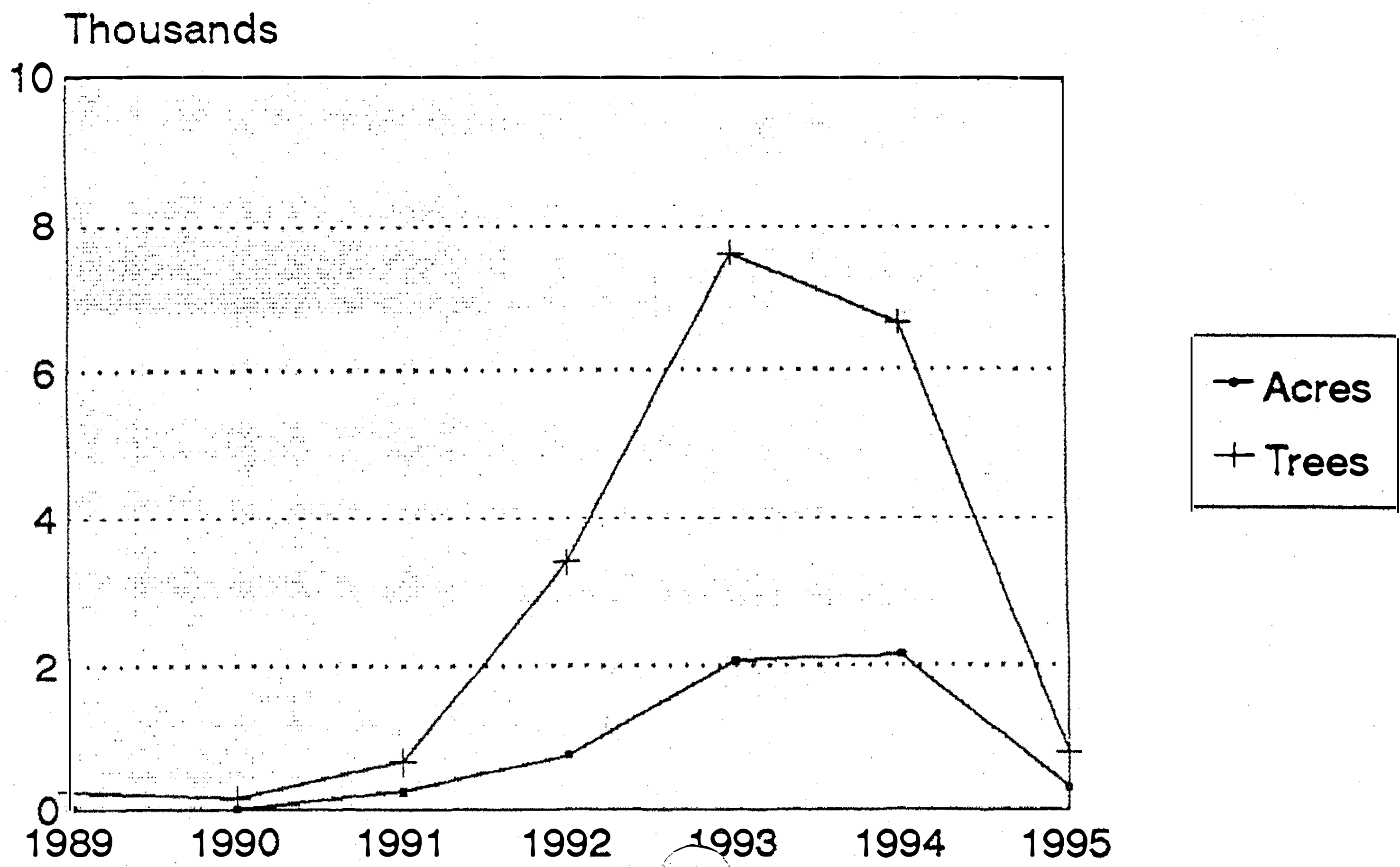


Table 1. Pre-Outbreak Basal Area per Acre by Species and Zone

Species	Zone 1	Zone 2	Zone 3
Aspen	0.0	12.7	1.8
Douglas-fir	127.5	32.7	27.3
Ponderosa Pine	*55.0	96.4	*87.3
White fir	25.0	9.1	5.4
SW White Pine	37.5	98.2	61.8
Total	*245.0	249.1	*183.6

* values for ponderosa pine and total basal areas for areas 1 and 3 include some estimates from stumps created following removal of hazard trees prior to the 1994 survey

Table 2. Pre-Outbreak Trees per Acre by Species and Zone

Species	Zone 1	Zone 2	Zone 3
Aspen	0.0	40.8	5.2
Douglas-fir	122.2	17.1	36.6
Ponderosa Pine	*48.4	106.4	*69.1
White fir	62.6	3.4	12.3
SW White Pine	57.0	130.2	85.8
Total	*290.2	297.9	*209.0

* values for ponderosa pine and total basal area for areas 1 and 3 include some estimates for stumps created following removal of hazard trees prior to the 1994 survey.

Table 3. Post-Outbreak Basal Area per Acre by Species and Zone (Live trees)

Species	Zone 1	Zone 2	Zone 3
Aspen	0.0	12.7	1.8
Douglas-fir	127.5	32.7	27.3
Ponderosa Pine	25.0	27.3	16.4
White fir	25.0	9.1	5.4
SW White Pine	35.0	90.9	58.2
Total	212.5	172.7	109.1

Table 4. Post-Outbreak Trees per Acre by Species and Zone (Live trees)

Species	Zone 1	Zone 2	Zone 3
Aspen	0.0	40.8	5.2
Douglas-fir	122.2	17.1	36.6
Ponderosa Pine	22.0	22.1	12.2
White fir	62.6	3.4	12.3
SW White Pine	53.8	121.0	82.8
Total	260.6	204.4	149.1

Table 5. Post Outbreak Ponderosa Pine Basal Area per Acre by Tree Condition and Zone

Zone	Live	Infested	Dead	Total	% Killed
1	25.0	0.0	*30.0	*55.0	55
2	27.3	0.0	69.1	96.4	71
3	16.3	3.6	*67.3	*87.3	77

* These values include some estimates from stumps created following removal of hazard trees prior to the 1994 survey

Table 6. Post Outbreak Ponderosa Pine Trees per Acre by Tree Condition and Zone

Zone	Live	Infested	Dead	Total	% Killed
1	22.0	0.0	*26.4	*48.4	55
2	22.1	0.0	84.3	106.4	79
3	12.2	2.8	*54.1	*69.1	78

* These values include some estimates from stumps created following removal of hazard trees prior to the 1994 survey

Table 7. SW White Pine Basal Area per Acre by Tree Condition and Zone

Zone	Live	Infested	Dead	Total	% Killed
1	35.0	0.0	2.5	37.5	6.7
2	92.7	1.8	3.6	98.2	5.5
3	58.2	3.6	0.0	61.8	5.8

Table 8. SW White Pine Trees per Acre by Tree Condition and Zone

Zone	Live	Infested	Dead	Total	% Killed
1	53.8	0.0	3.2	57.0	5.6
2	124.3	0.2	5.7	130.2	4.5
3	82.8	3.0	0.0	85.8	3.5

Table 9. Post Outbreak Ponderosa Pine Trees* per Acre by Diameter and Tree Condition for Zone 1

Diameter	Live	Infested	Dead	Total	% Dead
6	12.7			12.7	0
8			7.2	7.2	100
10			4.6	4.6	100
12			3.2	3.2	100
14			4.7	4.7	100
16	3.6		1.8	5.4	33
18	1.4			1.4	0
20	2.2		3.3	5.5	60
22				0.0	
24				0.0	
26	0.7		0.7	1.4	50
28				0.0	
30	1.0		0.5	1.5	33
32			0.4	0.4	100
34	0.4			0.4	0
Total	22.0	0.0	26.4	48.4	

* includes some estimates from stumps created following removal of hazard trees in the Riggs Campground prior to the 1994 survey.

Table 10. Post Outbreak Ponderosa Pine Trees per Acre by Diameter and Tree Condition for Zone 2

Diameter	Live	Infested	Dead	Total	% Dead
6	9.3		27.8	37.1	75
8			5.2	5.2	100
10			13.2	13.2	100
12	2.3		16.1	18.4	88
14	1.7		10.2	11.9	86
16			2.6	2.6	100
18	4.0		2.0	6.0	33
20	0.8		0.8	1.6	50
22	2.1		2.8	4.9	100
24	1.2		1.2	2.4	100
26			1.0	1.0	0
28			0.8	0.8	100
30	0.4			0.4	0
32	0.3		0.3	0.6	50
34				0.0	
36			0.3	0.3	100
Total	22.1	0.0	84.3	106.4	

Table 11. Post Outbreak Ponderosa Pine Trees per Acre by Diameter and Tree Condition for Zone 3*

Diameter	Live	Infested	Dead	Total	% Dead
6			9.3	9.3	100
8			5.2	5.2	100
10	3.3		3.3	6.6	50
12		2.3	4.6	6.9	66
14	5.1		13.6	18.7	66
16			5.2	5.2	100
18	1.0		4.0	5.0	80
20	1.7		2.4	4.1	58
22			1.4	1.4	100
24	0.6		1.2	1.8	67
26	0.5	0.5	1.5	2.5	60
28			2.0	2.0	100
20			0.4	0.4	100
Total	12.2	2.8	54.1	69.1	

* These values include some estimates from stumps created following removal of hazard trees in the Riggs Campground prior to the 1994 survey.